AD-A127 172    SMALL GROUPS IN PROGRAMMED ENVIRONMENTS: BEHAVIORAL AND        1/1
               BIOLOGICAL INTERA..(U) JOHNS HOPKINS UNIV BALTIMORE MD
               DIV OF BEHAVIORAL BIOLOGY  H H EMURIAN ET AL. 01 APR 83
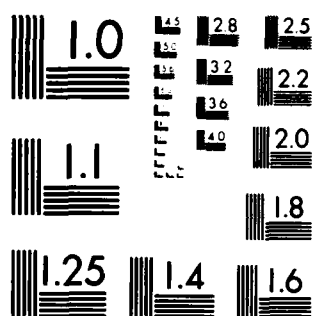UNCLASSIFIED   ONR-TR-8 N00014-80-C-0467                      F/G 5/10        NL

END
DATE
FILMED

DTIC

MICROCOPY RESOLUTION TEST CHART

NATIONAL BUREAU OF STANDARDS-1963-A

| REPORT DOCUMENTATION PAGE | | READ INSTRUCTIONS BEFORE COMPLETING FORM |
|---|---|---|
| 1. REPORT NUMBER<br>TR-ONR-8 | 2. GOVT ACCESSION NO. | 3. RECIPIENT'S CATALOG NUMBER |
| 4. TITLE (and Subtitle)<br><br>Small Groups in Programmed Environments:<br>Behavioral and Biological Interactions | | 5. TYPE OF REPORT & PERIOD COVERED<br>Technical Report |
| | | 6. PERFORMING ORG. REPORT NUMBER |
| 7. AUTHOR(s)<br><br>Henry H. Emurian and Joseph V. Brady | | 8. CONTRACT OR GRANT NUMBER(s)<br><br>N00014-80-C-0467 |
| 9. PERFORMING ORGANIZATION NAME AND ADDRESS<br>Division of Behavioral Biology<br>The Johns Hopkins University School of Medicine | | 10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS<br><br>NR 170-910 |
| 11. CONTROLLING OFFICE NAME AND ADDRESS<br>Organizational Effectiveness Research Programs<br>Office of Naval Research (Code 452)<br>Arlington, VA 22217 | | 12. REPORT DATE<br>1 April 1983 |
| | | 13. NUMBER OF PAGES<br>42 |
| 14. MONITORING AGENCY NAME & ADDRESS(If different from Controlling Office) | | 15. SECURITY CLASS. (of this report) |
| | | 15a. DECLASSIFICATION/DOWNGRADING SCHEDULE |

16. DISTRIBUTION STATEMENT (of this Report)


Approved for public release, distribution unlimited


17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)




18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)


Group performance, programmed environments

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This report reviews a research program undertaken within a laboratory environment that was designed and constructed to support behavior analyses of individual and group performance effectiveness viewed conceptually within the context of a small-scale human microsociety. Summarized are previous research emphases and findings in relationship to (1) conditions

DD FORM 1473 EDITION OF 1 NOV 65 IS OBSOLETE
1 JAN 73

that sustain group cohesion and productivity and that prevent social fragmentation and performance deterioration, (2) motivational effects resulting from the programmed consequences of individual and group performance requirements, and (3) behavioral and biological effects resulting from a change in group size. A more detailed description is presented of the results of a recent series of experiments that were conducted to assess performance and hormonal effects of replacing an established group participant with a novitiate member. The significance of these investigative undertakings is to be understood in terms of emergent environmental, motivational, and behavioral-biological principles having practical relevance for the establishment and maintenance of small-scale human social systems.

Accession For

NTIS GRA&I

DTIC TAB

Unannounced

Justification

By

Distribution/

Availability Codes

| Dist | Avail and/or Special |
|------|----------------------|
| A    |                      |

SMALL GROUPS IN PROGRAMMED ENVIRONMENTS:

BEHAVIORAL AND BIOLOGICAL INTERACTIONS[1]

## INTRODUCTION

Behavior analyses of small-scale human social systems have been
limited historically by the practical difficulties of conducting
experiments  in the natural ecology to identify factors that may influence
the status of members of such organizations.  Furthermore, reviews and
interpretations of the literature suggest that research on individual and
group effectiveness under laboratory conditions would be advantaged by a
more effective method for long-term analyses of human social systems within
the context of a comprehensive living and work setting (Thorndyke and
Weiner, 1980; Hare, 1976).  This paper, then, describes an experimental
methodology and representative results produced in the course of developing
a laboratory environment designed for the observation and measurement of
human behavior in small groups over extended time periods (e.g., weeks).
The background of this research program includes a discursive rationale and
model for the application of continuously programmed environments in human
research on the basis of extended experimental control, objective
recording, and the maintenance of realistic and naturalistic incentive
conditions for the assessment of a broad range of individual behavioral
processes (Findley, 1966).

## PROGRAMMED ENVIRONMENT

The residential laboratory consists of five rooms and an
interconnecting corridor, and it was constructed within a wing of The Henry

Phipps Psychiatric Clinic at The Johns Hopkins University School of Medicine. The floor plan of the laboratory and its position within the surrounding building shell are presented in Figure 1. Each private room (2.6 x 3.4 x 2.4 m) is similar to a small efficiency apartment containing kitchen, bathroom, bed, desk, etc. The recreation area (4.3 x 6.7 x 2.7 m) contains a complete kitchen facility along with exercise equipment and games. The workshop (2.6 x 4.1 x 2.7 m) contains operator consoles for individual and group performance tasks. A common bathroom serves the recreation and workshop areas. In summary, the programmed environment can accomodate at least three participants for intensive behavior analyses, and even more study subjects could be added to an experimental protocol by allowing additional members to reside temporarily within the recreation area along with their periodic rotations to the privacy of the individual rooms when solitary members move to the recreation area. Design drawings and photographs of the laboratory have been published elsewhere (Bigelow, Brady, and Emurian, 1975; Brady, Bigelow, Emurian, and Williams, 1975; Emurian, Brady, Ray, Meyerhoff, and Mougey, in press).

## BEHAVIORAL PROGRAM

To structure the subjects' use of the laboratory's resources in a disciplined yet meaningful way, a behavioral program was developed to establish and maintain individual and group performance baselines as well as to provide the context for experimental manipulations of performance interactions during extended residential studies. A behavioral program is defined by (1) an array of activities or behavioral units and (2) the rules
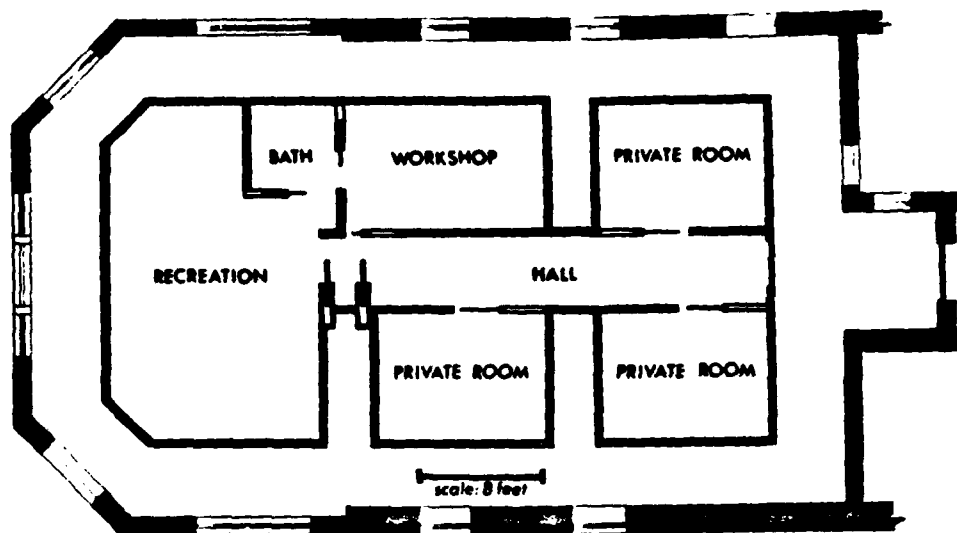
Figure 1. The floor plan of the laboratory, and its position within the
surrounding building shell.

governing the relationships between these activities. <u>Figure 2</u>, for example, illustrates diagramatically (1) the fixed and optional activity sequences that characterize a typical behavioral program used to establish baseline performances and (2) an array or inventory of component activities that constitutes such a program. Each box within the diagram represents a distinct behavioral unit and performance requirement, with progression through the various activities programmed sequentially from left to right. All behavioral units are scheduled on a contingent basis such that access to a succeeding activity depends upon satisfaction of the requirements for the preceding unit. Details regarding the composition of activities within the behavioral program are presented elsewhere (Emurian, Emurian, Schmier, and Brady, 1979).

## RESEARCH RESULTS

Over the past several years, over 150 volunteer subjects have participated in a series of group studies involving continuous residence for varying periods within the programmed laboratory environment. Subjects are normal volunteers with a college background, and they are accepted into the research program following psychological and medical examination, detailed orientations to the laboratory, and informed consent. Unless otherwise noted, the studies to be summarized herein were conducted with two-person and three-person male groups.

Early analyses involved observations of two-person groups for twenty-four-hour periods to demonstrate the adequacy of the hardware and to determine habitability under conditions that required minimal, and
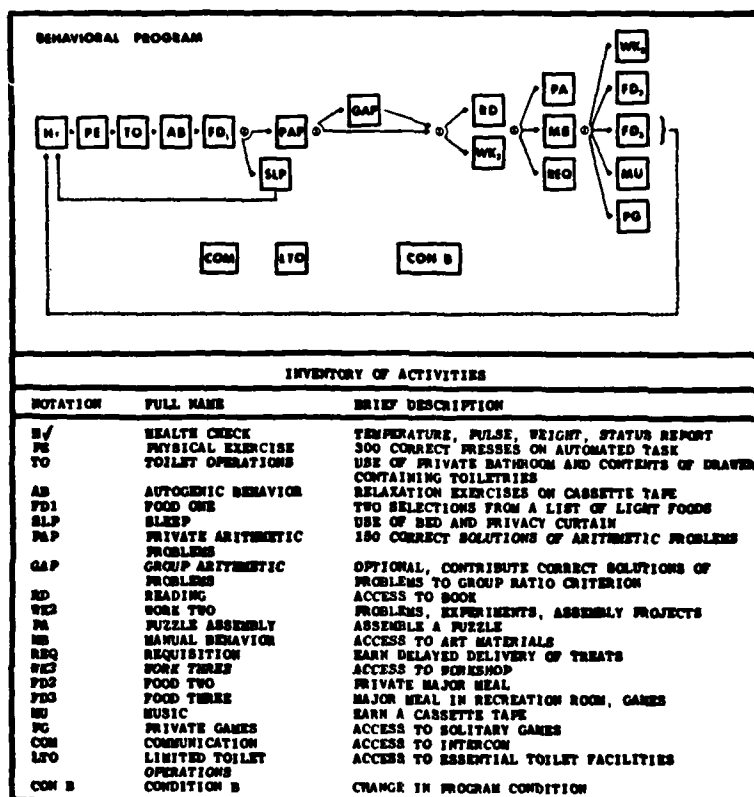
Figure 2. A diagrammatic representation of a typical behavioral program that governs the sequential and contingent relationships among the inventory of activities.

basically biological activity sequences, e.g., eating, sleeping, social interactions, etc. The major findings and conclusions were that the hardware was operational and the laboratory setting was capable of sustaining stress-free living conditions for at least these brief twenty-four-hour periods. The next phase of the research program extended the duration of residence from three to ten days during which time programmatic sequencing of performance units was introduced. The major findings and conclusions were not only that small groups could be maintained under stress-free living conditions for these more extended periods in the laboratory environment but also that the behavioral program was supportive of individual and group productivity (Emurian, Bigelow, Brady, and Emurian, 1975).

The utility and acceptability of the behavioral program was demonstrated further in a series of six-day to sixteen-day residential investigations that also revealed the sensitivity of behavioral effects to experimental "treatments" (Brady, Bigelow, Emurian, and Williams, 1975). Attention was then directed to ten-day analyses of the importance of social factors as they affect the status of a three-person microsociety. Those analyses showed that social contingencies, which required coordination among group members before access to the recreation area was granted, embedded within the behavioral program could counteract the tendency of a small-scale social system to fragment over time (Emurian, Emurian, Bigelow, and Brady, 1976). Such contingencies prevented persons with little interest in interacting socially from becoming isolated from the group and, in some cases, from showing a decline in individual performance

effectiveness (Brady and Emurian, 1979). Related experiments showed the reinforcing strength (i.e., appreciation by group members) of triadic social episodes, in contrast to dyadic episodes, and they indicated a relationship between social distance in a triad and time spent in a dyadic situation when social opportunities were limited to pairs of subjects (Emurian, Emurian, and Brady, 1978). Taken together, these studies indicated that low group cohesiveness increased members' vulnerability to social fragmentation in the absence of specifically programmed triadic contingencies of reinforcement that had the effect of promoting productive social interactions among group participants.

Whereas the preceding investigations were undertaken with incentives inherent within the behavioral program (subjects received a per diem allowance), the next set of studies introduced an interplay between incentives both internal and external to the program as the means of sustaining individual and group behavior. Those studies were designed to develop a laboratory model that would allow systematic exploration of individual and social by-products of avoidance incentive conditions (Emurian and Brady, 1979; Brady and Emurian, 1979). Under a positive incentive condition, "work units" (e.g., physical exercise, manual operations, mathematical calculations) were completed by individual group members, and the completion of each such unit resulted in a fixed increment to a group account that was divided evenly among the three subjects at the conclusion of the experiment. Under an avoidance incentive condition, however, no money was earned, group members were assigned a daily performance criterion to satisfy as a team, and failure to reach the

criterion resulted in reductions in accumulated earnings. The two incentive conditions appeared in various orders and durations across the series of investigations.

Comparisons between conditions on a number of behavioral program measures revealed the deleterious effects of the avoidance incentive condition. Disruptive by-products of that condition included (1) interpersonal confrontation and antagonism, especially by high-productivity subjects toward low-productivity subjects, (2) vociferous written and spoken complaints about the schedule, (3) written and spoken hostility directed toward the experimenters, and (4) dysphoric feelings. In contrast, under positive incentive conditions, such disruptive effects did not occur even when extraordinary performance productivity was observed, and a several-day history of negative effects could be overcome by reintroducing the positive condition. These effects emphasized the interaction between heterogeneity in work productivity within an organization and member tolerance and intolerance of such heterogeneity under different incentive conditions.

An example of one of the more extreme effects of avoidance incentive conditions was reflected in the performance data of the last experiment conducted in this series (Emurian, Emurian, and Brady, 1982). In this experiment, a Multiple Task Performance Battery (MTPB), presented on a CRT, replaced the work unit as the measure of complex human performance. The MTPB is composed of the following five subtasks that are presented simultaneously to an operator: (1) probability monitoring, (2) arithmetic

calculations, (3) warning light vigilance, (4) dynamic signal detection, and (5) target monitoring and recognition, (Emurian, 1978; Morgan and Alluisi, 1972). Accurate operation of the subtasks produces "accuracy points" that are cumulatively displayed on the CRT.

After two initial days under appetitive incentive conditions, the three-person group was assigned an MTPB avoidance criterion of 12,000 accuracy points to accomplish on each of Days 3-5 of this six-day study. Group members informally agreed to distribute the criterion evenly among themselves. At the conclusion of Day 4, however, Subject 3 fell behind in his share of work, and he caused the criterion to be missed by 56 points. Unlike a high-productivity participant's tolerance of variation in work output during the appetitive condition, one of the other group members (Subject 1) became openly hostile at this relatively trivial shortcoming, and he reprimanded Subject 3 during an intercom conversation at the end of Day 4. Significantly, Subject 1 also refused to perform any further work during the aversive condition, and on Day 5 the group lost heavily in potential earnings as a result, at least in part, of insufficient personnel to operate the performance battery on a sustained basis. Of at least equal importance was the fact that Subject 1's emotional outburst and his refusal to work was, in part, paralleled by Subject 2 who showed a markedly diminished output of work on Day 5. Neither Subject 2 nor Subject 3 showed a compensatory increase in work productivity on Day 5 that may have otherwise satisfied the criterion that was missed on that day by 6495 points. When the appetitive condition was reintroduced on Day 6, however, Subjects 1 and 2 again contributed to work output, and, indeed, all

subjects showed the greatest daily point accumulations on that final day of the experiment.

The behavioral effects observed in this last experiment were related to hormonal levels obtained from analyses of total urine volumes that were collected throughout the course of the experiment. Figure 3 shows the relationship for these three subjects between mean individual MTPB productivity per day and mean urine free cortisol per day determined by radioimmunoassay (Mougey, 1978). A direct relationship is evident between mean MTPB points per day and mean cortisol per day with the group member showing the highest average MTPB productivity (Subject 1, omitting Day 5) also showing the highest average cortisol level. Conversely, the group member showing the lowest average MTPB productivity (Subject 3) also showed the lowest average cortisol level. Significantly, Subject 1 was the high-productivity participant who refused to work on Day 5 of the study, and Subject 3 was the low-productivity participant who failed to reach the criterion on Day 4. These observations together suggest that sustained high productivity along with prolonged performance accuracy on a demanding task may render an individual vulnerable to disruptive emotional reactions such as those provoked by the avoidance phase of the study.

The foregoing investigations clearly established social variables as fundamental contributors to the overall status of a confined microsociety, and they emphasized the sensitivity of such variables to a range of experimental manipulations having operational significance. Throughout such studies, participants were observed to seek social interaction under
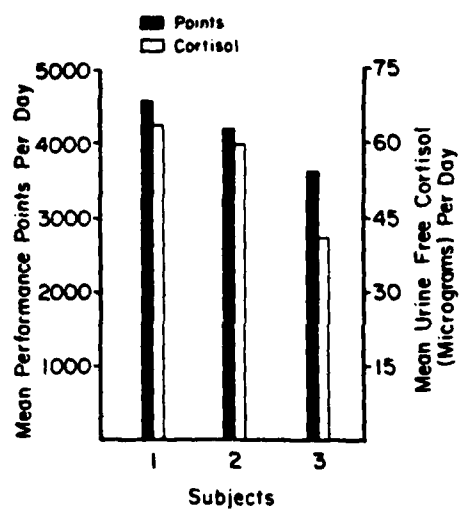
Figure 3. The relationship between mean MTPB points per day and mean urine free cortisol per day for all subjects.

one set of conditions (e.g., triadic social contingencies and positive performance outcomes) and to withdraw from such interaction under other conditions (e.g., pairing social contingencies and aversive performance outcomes). Thus, the joining and leaving of a group by participants under circumstances encompassing more than a single environmental condition appeared to generate social effects reflecting important dynamic processes requiring systematic experimental analysis.

Accordingly, studies were then conducted to assess the effects on individual and group behavior of a novitiate participant's introduction into and subsequent withdrawal from a previously established and stable two-person social system (Emurian, Brady, Meyerhoff, and Mougey, 1981). The objectives of these studies were to focus upon (1) the social mechanisms and temporal properties associated with the integration of such a participant into an established group, and (2) sources of group disruption or cohesiveness fostered by his or her presence. Additionally, measures of hormonal levels based upon the collection of total urine volumes throughout the course of the studies focused upon changes in the androgen testosterone as an endocrinological index of demonstrated sensitivity to social interaction effects in both animals (Eberhart, Keverne, and Meller, 1980; Bernstein, Rose, Gordon, and Grady, 1979) and humans (Scaramella and Brown, 1978; Elias, 1981). Such a behavioral biological analysis was implemented to provide a more comprehensive assessment of the personal and social impact generated by the introduction and withdrawal of new members with an established group (Frankenhauser, 1979).

Urinary testosterone levels were determined by radioimmunoassay.
Following a 72-hr hydrolysis with beta glucuronidase, the samples were
extracted with methylene chloride. The methylene chloride layer was washed
with water and dilute sodium hydroxide and then evaporated. The extracts
were purified on LH-20 Sephadex columns. Recoveries through the procedure
were monitored by the addition of a small amount of tritiated testosterone
added to each sample prior to extraction. The Sephadex column eluates were
evaporated and taken up in RIA buffer. Aliquots were incubated overnight
at $4^{\circ}C$ with a testosterone antibody produced in rabbits. Free and
antibody-bound hormone was separated using Somogyi reagents. Radioactivity
measurements were made in a Beckman LS-250 counter. Samples were assayed
in duplicate and corrected for recovery.

The paradigm adopted for experimental analyses of effects of changes
in group size and composition was as follows. A two-person group resided
for ten successive days within the programmed environment, and members of
that dyadic team operated performance tasks for their earnings. During the
course of that ten-day period, a third "novitiate" participant was
introduced into the programmed environment for several successive days,
thereby increasing the size of the group from two to three members. A
typical "introduction" period lasted four days, and it usually began on Day
4 or Day 7 of a ten-day experiment.

The rule conditions of the behavioral program that were associated
with the novitiate's entrance into the group differed across successive
investigations. In some studies, the novitiate received a per diem

allowance, and he was not required to work for compensation, although he was permitted to operate to the performance tasks that advantaged the two established group members. In other studies, the novitiate was required to work for compensation by competing with the two other group members for access to the single work task console located within the workshop. Finally, the series of investigations was undertaken with both male and female novitiates and, in some cases, with novitiates and dyadic members who had previously participated in earlier residential studies.

In studies where the novitiate's presence primarily served as additional social stimulation for the established dyad and as a source of information regarding current events outside the laboratory, the two-person group showed a resistance to granting the novitiate permission to work, even when such work would have provided relief from operating a demanding task. Importantly, however, as the three-person condition continued over days, novitiates were observed to contribute to work productivity to a degree that was almost equivalent to the productivity of the dyadic members. Since there were no external incentives for a novitiate's work in these first introduction studies, these findings emphasized the influence of social processes alone in maintaining performance productivity at least within these cohesive group situations.

Transitions between two-person and three-person conditions were not always smooth in groups where the novitiate had to work for compensation. When a novitiate forcefully intruded himself into the dyad's customary work schedule, his testosterone levels rose or fell generally in close

relationship to his success or failure, respectively, to gain and maintain
access to the work station according to a schedule that was least
disruptive to his wake-sleep cycles as determined during several baseline
days preceding his introduction into the group.  When sleep discipline was
imposed, and when a novitiate was cooperative in negotiating an orderly
sequence of using the work task console, notable changes in testosterone
were not observed in any participant.  When a female novitiate was
introduced into a two-man group, wake-sleep cycles and work periods were
erratic throughout the three-person condition.  Such effects were
associated with the absence of notable androgen changes, even by a dyadic
member who, as a novitiate in an earlier study, had successfully maintained
his wake-sleep cycles and had shown a striking increase in testosterone
when he joined the group.

The most recent series of experiments demonstrated the extension of
the research paradigm from analyses of "introduction" effects to the
analysis of "replacement" effects.  Whereas the previous investigations
changed group size as an experimental variable or treatment, subsequent
studies held group size constant to evaluate effects of replacing a member
of an established three-person group with a novitiate participant.  These
replacement analyses, then, involved important elements of continuity with
the earlier studies in the manner of being systematic replications of those
investigations.  In a research strategy based upon systematic replications,
in contrast to exact or direct replications, effects of the experimental
variable or treatment are demonstrated by affirming the consequent (Sidman,
1960), in which case each successive replication incrementally contributes

to an understanding of effects that can be reliably attributable to the antecedent condition ($\underline{e}$.g., introductions or replacements). The generality of the behavioral processes is assured by showing similar relationships across a broad range of circumstances ($\underline{e}$.g., subjects, order and duration of experimental conditions, performance tasks, group size, etc.). This research strategy as adopted by the programmed environment unit has proved to be most productive and economical, especially in light of the expense and staffing effort required to undertake programmed environment investigations.

A typical replacement investigation proceeded as follows. An original three-person group resided in the programmed environment for five successive days. At the end of Day 5, one of the original group members was withdrawn, and he was replaced by a novitiate participant who, along with the remaining two original members, formed a new group for the next five successive days.

For the first replacement experiment (G-1), three-person group members resided in their private rooms for a two-day baseline "alone" period during which time access to the intercom, to social activities, and to the MTPB work station was prohibited. This two-day period provided a necessary hormonal reference against which to assess endocrine responses in relationship to initial group formation. On Day 3, all activities previously prohibited were made available to the group, and each member was required to operate the MTPB for individual compensation. As in the introduction experiments, there was only one MTPB console located within

the workshop, and subjects occupied the workshop singly on a
self-determined rotational basis.  This procedure, then, permitted an
evaluation of the manner in which subjects occupied the work station (e.g.,
duration of work periods, time-of-day of work periods, etc.) as one of the
principal dependent variables of the experiment.

At the end of Day 5, whoever of the three mission members had earned
the fewest MTPB performance points, totalled across Days 3-5, was withdrawn
from the experiment.  This decision rule was known by the group members
before the experiment began.  The novitiate participant entered the
programmed environment on Day 6, which was a solitary baseline day for all
three subjects.  On Day 7, the newly formed group had access to intercom
communications, social activities, and the MTPB work station that continued
to be available throughout Days 7-10.  Thus, the two ten-day participants
were required to adjust to the replacement of an original member, and the
novitiate member was required to adjust to his entrance into an established
unit whose members shared a history of having competed successfully to
maintain high levels of performance effectiveness.

Figure 4 presents time of day spent working on the MTPB for all
subjects across successive days of the experiment when access to work was
permitted.  The novitiate participant is identified as "S4."  Throughout
Days 3-5, subjects alternated in their occupancy of the work station, with
uninterrupted work periods ranging from two hours (e.g., S1, Day 3) to 9
hours (e.g., S2, Day 4).  The lengthy work period exhibited by S2 on Day 4
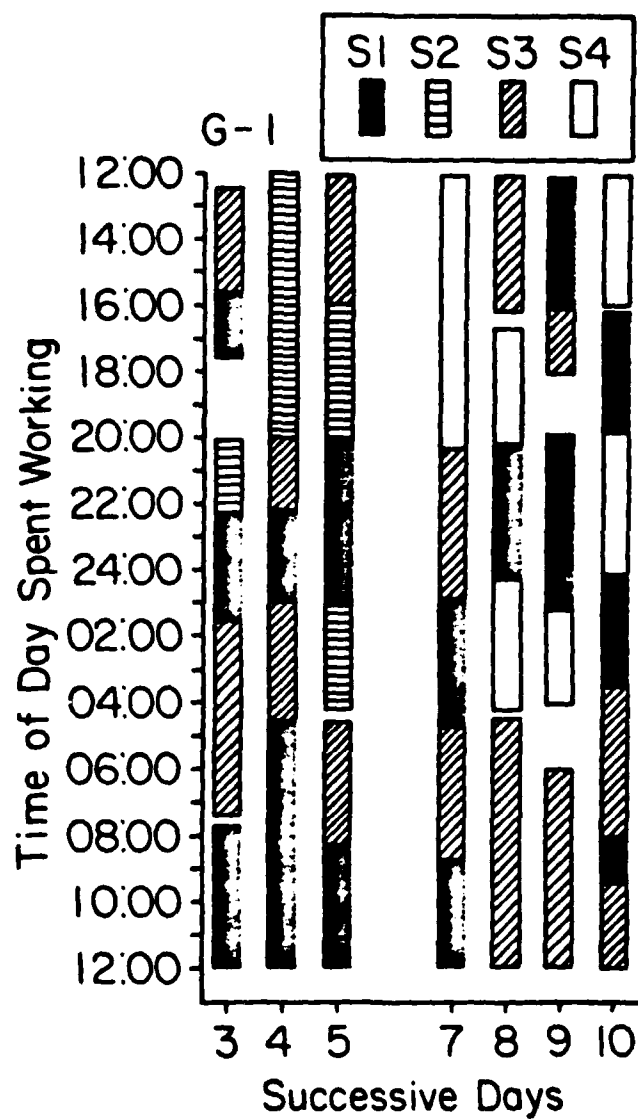was attributable to his attempt to remain competitive after having worked

Figure 4. Time of day spent working on the MTPB for all subjects within Group 1 across successive days of the experiment.

only two hours on Day 3. When the novitiate (S4) began to work on Day 7, having replaced S2, he initially preempted the work station for at least nine uninterrupted hours of MTPB performance. That the other group members were unappreciative of this intrusion was indicated quantitatively by the negative interpersonal ratings assigned to S4 during the Health Check activity. Thereafter, the novitiate and the remaining group members alternated occupancy of the work station, with S3 clearly showing work times later in the day in contrast to his work times during Days 3-5. Neither the original group nor the reformed group showed stability across days of work times, and this outcome is perhaps attributable to the competitive contingencies for individual compensation that were present throughout all work days.

Figure 5 shows time of day spent sleeping for all subjects across successive days of the experiment. Comparatively stable sleep patterns were exhibited only by S2 who showed uninterrupted sleep episodes beginning between 2400 and 0500 hours across Days 1-5. During the same five-day period, Subjects 1 and 3 almost always showed erratic sleep episodes that differed across days in time of day of occurrence, frequency, and duration. Similar erratic patterns persisted during Days 6-10 when S2 was replaced by the novitiate (S4). Importantly, the novitiate showed the most consistent sleep periods across days, and S3 showed a clear reorientation in his sleep episodes that persisted throughout Days 7-10. These latter effects reflect the readjustments that were required by at least one original group member when the novitiate became a working participant during Days 7-10 of the experiment.
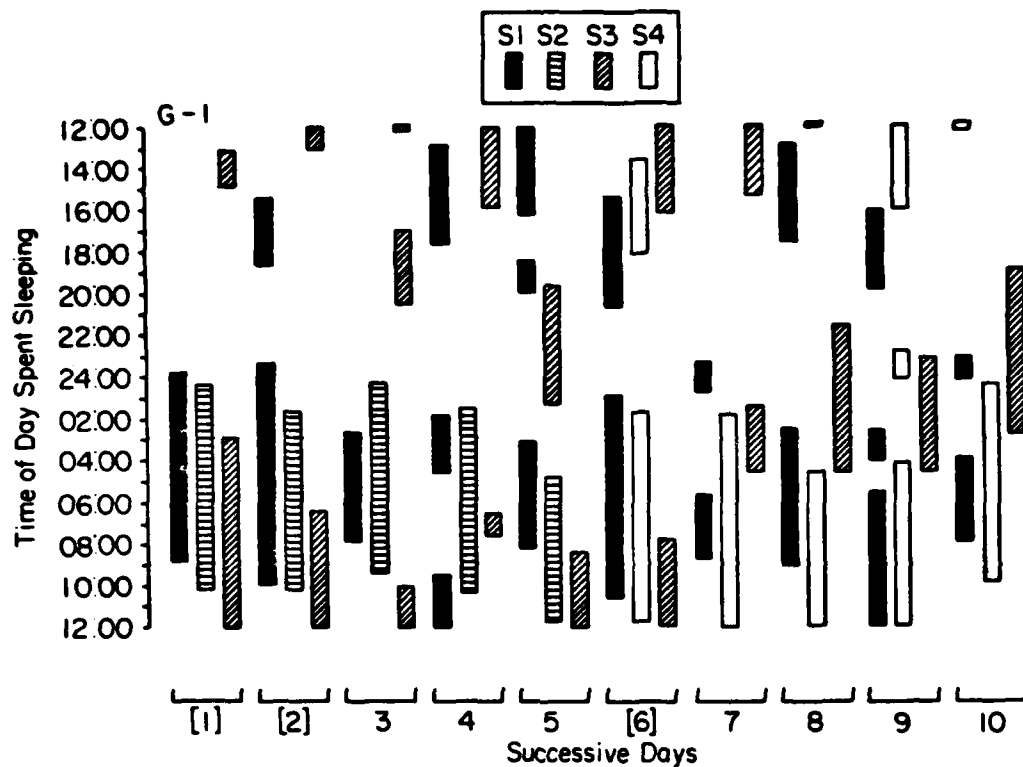
Figure 5. Time of day spent sleeping for all subjects within Group 1
across successive days of the experiment. Bracketed days are
baseline "alone" days.

Figure 6 shows total urinary testosterone for all subjects across successive days of the experiment. With respect to the original group members, S2 showed testosterone values that were somewhat lower than the other two participants. Importantly, these comparatively lower values were evident during the first two baseline days of the experiment. When group members commenced working on Day 3, S2's values increased somewhat over baseline levels, but they continued to be below the values exhibited by the other members across Days 3-5. Significantly, S2 was the group member who did not compete successfully to remain within the experiment for ten days, and he was withdrawn at the conclusion of Day 5. Finally, across Days 7-10, testosterone levels progressively declined for S3 in relationship to his shift in work and sleep times.

The experimental design plan of the second replacement analysis (G-2) was similar to the first with two differences. First, the novitiate group member was a female who had previously participated in an unrelated ten-day residential experiment, and she had almost 60 hours' practice on the MTPB. Second, to provide more days for competition to remain within the experiment and a longer history of sustained performance effectiveness by two group members prior to the novitiate's entrance, no initial baseline was programmed. The novitiate, then, entered the environment at the beginning of Day 6, which was a baseline day for all subjects, with more experience in the laboratory than the other two group members. Thus, the two ten-day participants were required to adjust to the replacement of an original group member by a person having extensive programmed environment experience.
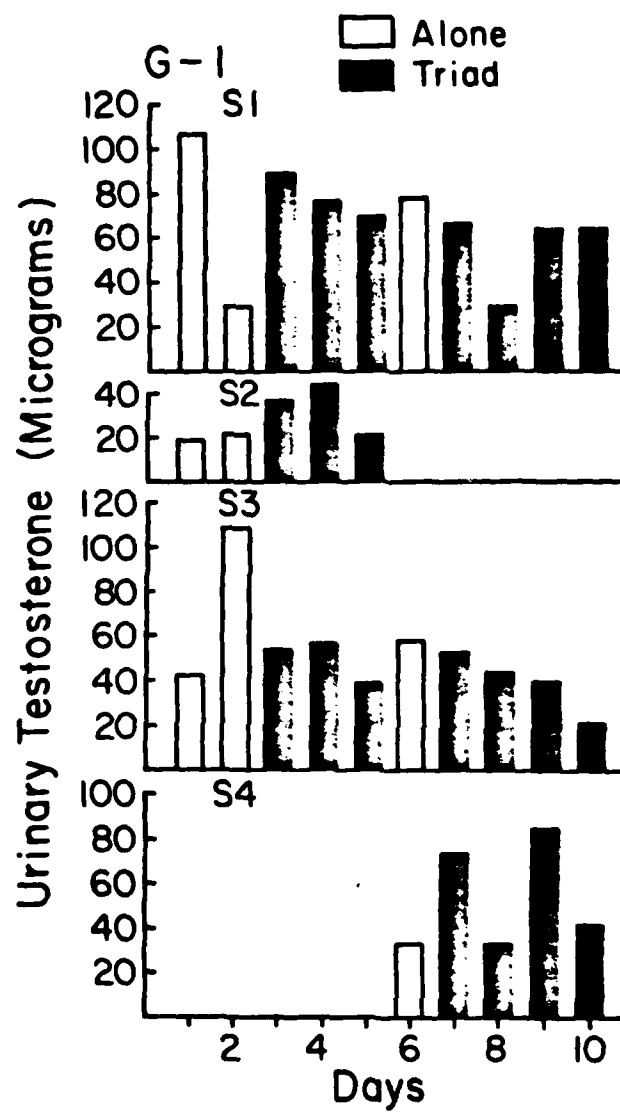
Figure 6. Total urinary testosterone for all subjects within Group 1 across successive days of the experiment.

Figure 7 presents time of day spent working on the MTPB for all
subjects across successive days of the experiment when access to work was
permitte.. The novitiate participant is identified as "S4." Throughout
Days 1-3, subjects alternated occupancy of the work station in an erratic
fashion within and across days, with work periods lasting between 1 hour
(e.g., S1, Day 1) and 8 hours (e.g., S1, Day 3). Subject 3 voluntarily
withdrew from the experiment during Day 3, reasoning that his performance
would not result in his participation beyond Day 5. Since the novitiate
was not scheduled to appear until Day 6, a planned baseline day for all
subjects, the two remaining subjects were programmed with baseline days on
Days 4 and 5. This preserved the integrity of the experimental design in
relationship to analyses of three-person working groups. In striking
contrast to work times during Days 1-3, work times during Days 7-10 were
orderly and precise. The pattern for Day 8 was identical to Day 7, and the
pattern for Day 10 was identical to Day 9. Throughout Days 7-10, all
subjects occupied the work station for eight hours each day.

These data show the impact of an experienced person, who exhibited
assertiveness and leadership, on an established group whose members had
previously competed successfully to remain within the experiment. Although
the two-person group followed the suggestions, if not the directions, of
the novitiate, S4 received negative interpersonal ratings on the Health
Check questionnaire.

Figure 8 presents time of day spent sleeping for all subjects across
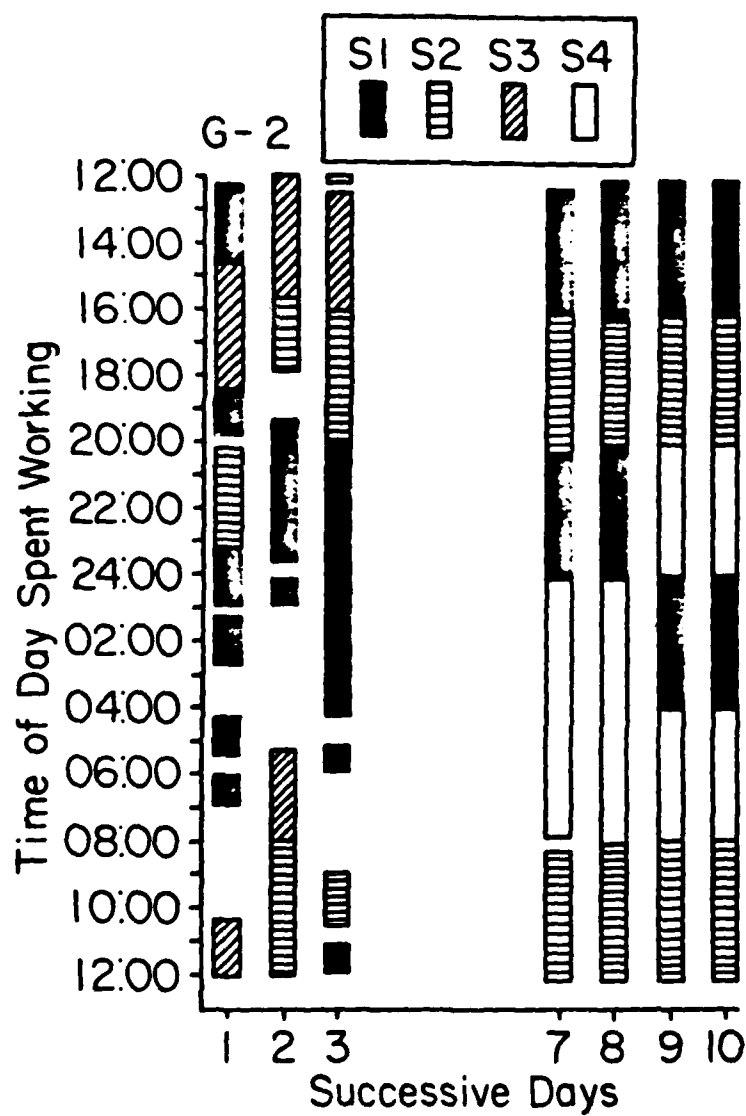successive days of the experiment. Although sleep times were perhaps not

Figure 7. Time of day spent working on the MTPB for all subjects within Group 2 across successive days of the experiment when work was permitted.
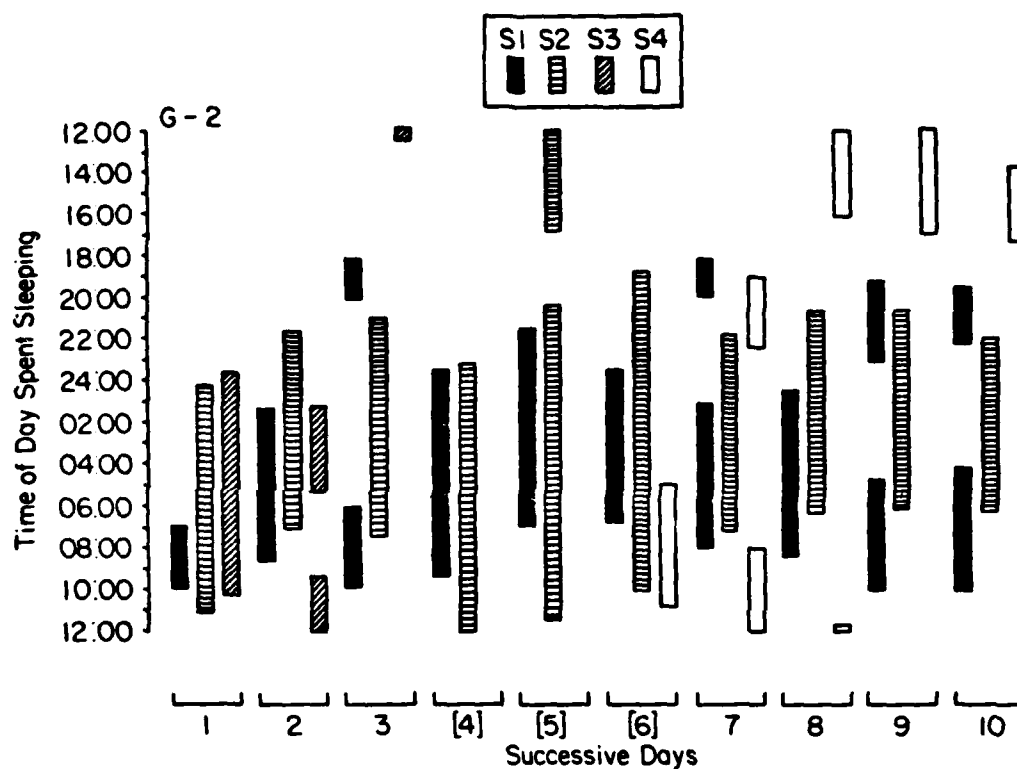
Figure 8. Time of day spent sleeping for all subjects within Group 2 across successive days of the experiment. Bracketed days are baseline "alone" days.

as erratic as those in the previous experiment, only S2 showed patterns
that were somewhat consistent across days. Additionally, the novitiate
shifted her sleep pattern on Day 8, and she thereafter commenced sleep
periods in the early hours (e.g., 1200) of an experimental "day." Finally,
the stable sleep patterns exhibited by subjects on Days 9 and 10
corresponded to stable work periods also observed on those two final days.

Figure 9 shows total urinary testosterone for all subjects across
successive days of the experiment. Most notable in these data is the
pronounced drop in testosterone by S3 between Days 1 and 2. Significantly,
S3 was the group member who voluntarily withdrew from the experiment on Day
3. The absence of clear androgen changes across conditions by Subjects 1
and 2 is consistent with the absence of clear shifts in their wake-sleep
cycles as a function of the change in group membership. In this regard,
however, S4 (the female) showed a shift in her wake-sleep cycles between
baseline and work days, and her testosterone values were lower than
baseline on three of the four work days (Days 7, 8, and 10). These
relationships, along with those observed in G-1, are similar to those that
emerged from the "introduction" experiments, and they demonstrate, by
systematic replication, the generality of the behavioral-biological
processes that govern such effects.

## DISCUSSION

The results of these experiments show clearly that interactive
behavioral and biological processes are prominently involved in the
individual performance adjustments and social adaptations of small groups
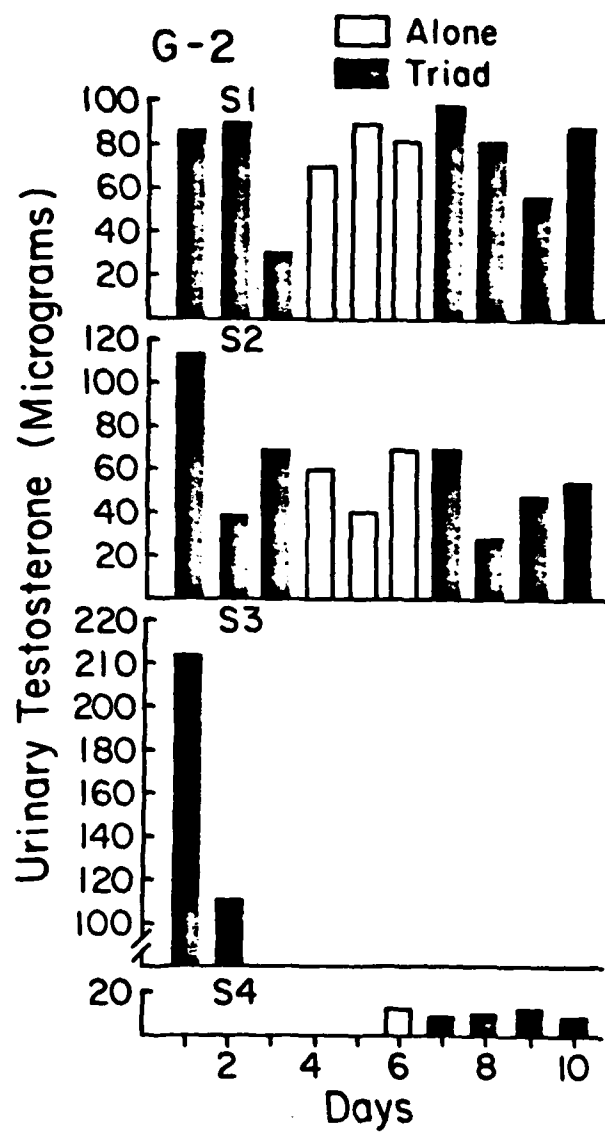
Figure 9. Total urinary testosterone for all subjects within Group 2 across successive days of the experiment.

in a confined microsociety. Of particular interest in this regard are the observations that implicate the behavioral-biological interactions in those aspects of endocrine regulation reflected in the cortisol and testosterone measurements. While the positive relationship between corticosteroid levels and individual work productivity is generally consistent with the catabolic influence presumed to be exerted by these hormones on energy metabolism (Mason, 1968), the interactions between androgen levels and both individual and group performance dynamics present a more complex interpretive problem.

The suggested interaction between broadly defined "dominance-submission" relationships and testosterone levels in the present series of studies conforms well with the observations reported on changes in group composition and organization in lower primates. Under conditions that involved the introduction of a new rhesus monkey into an existing group, changes in testosterone levels among high-ranking males were observed to be functionally related to an animal's success (or failure) in defending his status in the primate social order. Victorious animals showed significant increases in testosterone levels (Bernstein, Rose, and Gordon, 1974) while monkeys defeated by the group were reported to show marked androgen level decreases (Rose, Gordon, and Bernstein, 1972). These relationships were further confirmed in experiments that involved the merging of two established groups, with defeated alpha males showing a decrease and victorious alpha males an increase in androgen levels (Bernstein, Rose, Gordon, and Grady 1979). It must be emphasized, of course, that these studies with laboratory monkeys occurred under

conditions that involved intense and enduring aggressive confrontations unlike anything observed in the much more benign exchanges among the humans participating in the present group interaction experiments. But at least one investigation with human subjects has suggested a relationship between plasma testosterone levels and the outcome of physical conflict where winners of a competitive wrestling match showed greater increases in testosterone than losers (Elias, 1981). Taken together, then, the general conformity in environmental-endocrinological relationships described under these several investigative circumstances suggests a continuity across species of these fundamental behavioral-biological processes.

The significance of the observed behavioral-biological interactions is to be understood in terms of the completeness of the resulting account of effects of an experimental variable (e.g., the introduction of a novitiate into an established group or the replacement of an established group member by a novitiate). With regard to the relevance of the endocrinological relationships observed under such conditions, it seems reasonable to suggest that the adaptive significance of any hormonal response can best be interpreted in terms of the effects of that response at the metabolic level. Although research on the androgens has typically emphasized reproductive functions, it has been established that testosterone has potent "anabolic" properties, promoting protein synthesis in muscle and many other tissues (Dorfman and Shipley, 1956; Kochakian, 1964, 1975) and potentiating some effects of insulin on carbohydrate metabolism (Talaat, Habib, and Habib, 1957). Whether these "anabolic" effects of testosterone and androgenic metabolites play any appreciable role in general organic or

energy metabolism must, of course, await clarification by further investigative analysis. But at the very least, the present series of experiments emphasizes the importance of a multidimensional analysis of the behavioral and biological interactions that determine the adaptations and adjustments of small groups in confined microsocieties.

# REFERENCES

Bernstein, I.S., Rose, R.M., and Gordon, T.P. Behavioral and
environmental events influencing primate testosterone levels.
Journal Evol., 1974, 3, 517-525.

Bernstein, I.S., Rose, R.M., Gordon, T.P., and Grady, C.L.
Agonistic rank, aggression, social context, and testosterone in
male pigtail monkeys. Aggressive Behavior, 1979, 5, 329-339.

Bigelow, G.E., Emurian, H.H., and Brady, J.V. A programmed
environment for the experimental analysis of individual and small
group behavior. In C.G. Miles (Ed.), Experimentation in
Controlled Environments: Its Implications for Economic Behavior
and Social Policy Making. Toronto: Alcoholism and Drug
Addiction Research Foundation of Ontario, 1975, 133-144.

Brady, J.V. and Emurian, H.H. Behavior analysis of motivational
and emotional interactions in a programmed environment. In R.
Dienstbier and R. Howe (Eds.), Nebraska Symposium on Motivation,
Lincoln: University of Nebraska Press, 1979.

Brady, J.V., Bigelow, G.E., Emurian, H.H., and Williams, D.M.
Design of a programmed environment for the experimental analysis
of social behavior. In D.H. Carson (Ed.), Man-Environment
Interactions: Evaluations and Applications. 7: Social Ecology,
1975, 187-208.

Dorfman, R.I., and Shipley, R.A.  Androgens.  New York:  Wiley, 1956, 218.

Eberhart, J.A., Keverne, E.B., and Meller, R.E.  Social influences on plasma testosterone levels in male talopoin monkeys.  Hormones and Behavior, 1980, 14, 247-266.

Elias, M.  Serum cortisol, testosterone, and testosterone-binding globulin responses to competitive fighting in human males. Aggressive Behavior, 1981, 7, 215-224.

Emurian, H.H.  A multiple task performance battery presented on a CRT.  JSAS Catalog of Selected Documents in Psychology, 1978, 8, 102.

Emurian, H.H., and Brady, J.V.  Small group performance and the effects of contingency management in a programmed environment:  A progress report.  JSAS Catalog of Selected Documents in Psychology, 1979, 9, 58.

Emurian, H.H., Emurian, C.S., and Brady, J.V.  Appetitive and aversive reinforcement schedule effects on behavior:  A systematic replication.  Basic and Applied Social Psychology, 1982, 3(1), 39-52.

Emurian, H.H., Emurian, C.S., and Brady, J.V.  Effects of a pairing contingency on behavior in a three-person programmed environment.  Journal of the Experimental Analysis of Behavior, 1978, 29,

319-329.

Emurian, H.H., Bigelow, G.E., Brady, J.V., and Emurian, C.S. Small group performance maintenance in a continuously programmed environment. JSAS Catalog of Selected Documents in Psychology, 1975, 5, 187.

Emurian, H.H., Brady, J.V., Meyerhoff, J.L., and Mougey, E.H. Behavioral and biological interactions with confined microsocieties in a programmed environment. In Grey, J. and Hamden, L.A. (Eds.), Space Manufacturing 4. New York: American Institute of Aeronautics and Astronautics, 1981, 407-421.

Emurian, H.H., Emurian, C.S., Schmier, F.R., and Brady, J.V. Notes on programmed environment research. JSAS Catalog of Selected Documents in Psychology, 1979, 9, 66.

Emurian, H.H., Bigelow, G.E., Brady, J.V., and Emurian, C.S. Small group performance maintenance in a continuously programmed environment. JSAS Catalog of Selected Documents in Psychology, 1976, 5, 187.

Emurian, H.H., Emurian, C.S., Bigelow, G.E., and Brady, J.V. The effects of a cooperation contingency on behavior in a continuous three-person environment. Journal of the Experimental Analysis of Behavior, 1976, 25(3), 293-302.

Emurian, H.H., Brady, J.V., Ray, R.L., Meyerhoff, J.L., and Mougey,

E.H. Experimental analysis of team performance. Naval Research Reviews, in press.

Findley, J.D. Programmed environments for the experimental analysis of human behavior. In W. Honig (Ed.), Operant Behavior: Areas of Research and Application. New York: Appleton-Century-Crofts, 1966.

Frankenhauser, M. Psychoneuroendocrine approaches to the study of emotion as related to stress and coping. In R. Dienstbier and R. Howe (Eds.), 1978 Nebraska Symposium on Motivation, Lincoln: University of Nebraska, 1979.

Hare, A.P. Handbook of Small Group Research. New York: Free Press of Glencoe, 1976.

Kochakian, C.D. Definition of androgens and protein anabolic steroids. Pharmacological Therapeutics B., 1975, 1(2), 149-177.

Kochakian, C.D. Protein anabolic property of androgens. Alabama Journal of Medical Science. 1: 24, 1964.

Mason, J.W. Organization of the multiple endocrine responses to avoidance in the monkey. Psychosomatic Medicine, 1968, 30, 774-790.

Morgan, B.B. and Alluisi, E.A. Synthetic work: Methodology for the assessment of human performance. Perceptual and Motor Skills, 1972, 35, 835-845.

Mougey, E.H.  A radioimmunoassay for tetrahydrocortisol.
Analytical Biochemistry, 1978, 91, 566-582.

Rose, R.M., Gordon, T.P., and Bernstein, I.S.  Plasma testosterone
levels in the male rhesus:  Influences of sexual and social
stimuli.  Science, 1972, 178, 643-645.

Scaramella, T.J. and Brown, W.A.  Serum testosterone and
aggressiveness in hockey players.  Psychosomatic Medicine., 1978,
40, 262-265.

Sidman, M.  Tactics of Scientific Research.  New York:  Basic
Books, 1960.

Talaat, M., Habib, Y.A., and Habib, M.  The effect of testosterone
on the carbohydrate metabolism in normal subjects.  Archives of
Internal Pharmacodynamics, 111:  215, 1957.

Thorndyke, P.W. and Weiner, M.G.  Improving Training and
Performance of Navy Teams:  A Design for a Research Program.
Santa Monica:  RAND, 1980.

FOOTNOTES

## DISTRIBUTION LIST

Defense Technical Information Center
ATTN:  DTIC DDA-2
Selection and Preliminary Cataloging Section
Cameron Station
Alexandria, VA  22314

Library of Congress
Science and Technology Division
Washington, DC  20540

Office of Naval Research
Code 452
800 N. Quincy Street
Arlington, VA  22217

Naval Research Laboratory
Code 2627
Washington, DC  20375

Office of Naval Research
Director, Technology Programs
Code 200
800 N. Quincy Street
Arlington, VA  22217

Office of Naval Research
Code 450
800 N. Quincy Street
Arlington, VA  22217

Office of Naval Research
Code 458
800 N. Quincy Street
Arlington, VA  22217

Office of Naval  Research
Code 455
800 N. Quincy Street
Arlington, VA  22217

Colonel Shirley J. Bach
Director, Defense Equal Opportunity
  Management Institute
Patrick, AFB, Florida  32925

Major Ray Belongie, USMC
Headquarters, United States Marine Corps
(Code MPH)
Washington, D.C.  20380

Della J. Bossart
Equal Opportunity Division (N-61)
Naval Military Personnel Command
Washington, D.C.  20370

Dr. Stuart W. Cook
Institute of Behavioral Science, Bldg #5
University of Colorado
Boulder, Colorado  80309

Lt. Del Cruz
Navy Recruiting Command
BT #2, Room 1001
Arlington, Virginia  22217

Mr. Reginald M. Felton
Chief of Naval Operations (OP-14C)
Navy Annex
Washington, D.C.  20350

Captain Dana French
Chief of Naval Operations
OP-150
Washington, D.C.  20350

Dr. Antoine Garibaldi
1200 19th Street N.W.
Washington, D.C.  20208

Dr. Richard Hope
Department of Anthropology and
  Sociology
Morgan State University
Baltimore, Maryland  21239

Dr. James Jones
American Psychological Association
1200 Seventeeth Street N.W.
Washington, D.C.  20036

Dr. Frank Landy
Department of Psychology
Penn State University
University Park, Pennsylvania  16802

Dr. Al Lau
Navy Personnel Research and
  Development Center
San Diego, CA   92152

Dr. James Lester
Psychologist
ONR-Eastern-Central Regional
Building 114
Section D
666 Summer Street
Boston, MA   02210

Dr. Kenneth Martinez
P.O. Box 824
Lawrence, Kansas

Dr. Douglas McCann
Ohio State University
404C West 17th Avenue
Columbus, Ohio   43210

Ms. Sandra Mumford
Navy Department (NMPC-623)
Washington, D.C.   20370

Dr. Thomas M. Ostrom
404C West 17th Avenue
Columbus, Ohio   43210

Captain Buddy Penn
Chief of Naval Operations
OOE
Washington, D.C.   20350

Dr. John Pryar
404C West 17th Avenue
Columbus, Ohio   43210

Dr. David Stonner
Organizational Effectiveness
  Research Program
Department of the Navy
Office of Naval Research
800 N. Quincy Street
Arlington, VA   22217

Ms. Janie Taylor
Chief of Naval Material
Navy Department
Washington, D.C.  20360

Captain Edward Titus
Human Resource Management Center,
  Washington
Commonwealth Building, Room 1158
1300 Wilson Blvd.
Arlington, Virginia  22209

Dr. Harry C. Triandis
Psychology Building
603 E. Daniel Street
Champaign, Illinois  61820

Army Research Institute
5001 Eisenhower Avenue
Alexandria, VA  22333
ATTN:  Technical Director

Dr. F. W. Hegge
MDRDC
Walter Reed Army Institute
  of Research
Division of Neuropsychiatry
Washington, DC  20012

Dr. Al Fregley
Program Manager, Life Science
  Directorate
AFOSR/NL, Bldg. 410
Bolling AFB
Washington, DC  20332

Dr. Stanley Deutsch
Office of Life Science
NASA
600 Independence Avenue
Washington, DC  20546